J. Union Arab Biol, Cairo
Vol. 5(B), Botany, 59-78, Feb. 98
Rec. 1/1/1998

ISSN 1110-5380
Egyptian-Swedish Symposium
Commemorating Vivi Täckholm's 100th
Birthday 8-11 Feb., 1998

DOES PHYTO-DIVERSITY COINCIDE WITH ZOO-DIVERSITY IN EGYPT?

SAMIR I. GHABBOUR AND WAFAÏ Z. A. MIKHAIL

Dept. of Natural Resources, Inst. of African Research and Studies,

Cairo University, 12613 Giza (Cairo), Egypt

Key words : Egypt - Biodiversity - Biogeography - Flora - Fauna - Hot spots.

SUMMARY

Since the signing of the International Convention on Biological Diversity (CBD) in Rio in 1992, most countries of the world have become committed to the safeguard and protection of their biodiversity resources. Prior to this, it is essential to know first what a country has, and where. Serious surveying and mapping of biodiversity efforts started to be a major concern of Governments, for establishing detailed distribution maps for plants and animals in the country, in order to make the right decisions about their conservation, on how and where to invest money in establishing nature reserves. Such reserves are thought to be best established in areas of rich biodiversity, particularly those areas whose rich biodiversity is under threat of vanishing, due to a variety of factors. These areas are now known as "Hot Spots". There is need therefore to put biodiversity on maps, at various levels and on various scales: global, regional, national. and sub-national. For the national scale, three ways of representation are available: the biogeographical regions of the country, the administrative divisions, and a neutral grid of squares overlain on the map of the country. Such maps, to be useful, must combine all possible taxa, not a few only, because a Government needs to obtain the fullest possible advantage of its conservation efforts. The distribution of plant diversity in Egypt, as well as for butterflies and for reptiles, has been made on the scale of bio- (or rather phyto-) geographical regions, and for birds, at the scale of a half-degree grid of squares. There is no other known attempt yet, to combine and compare the biodiversity of plants and other taxa of the Animal Kingdom. In the present paper, the diversity (as species numbers) of 12 taxa from the Animal Kingdom is compared with the diversity of higher plants, to see if they coincide. Results show that, generally, and as a first approximation, the Nile land combines the highest number of taxa with the richest biodiversity of both Kingdoms, while the Western Desert is the region with the lowest biodiversity of all taxa examined. The study has shown that biotic interactions are not the sole determinant of the coincidence of phyto-diversity with zoo-diversity. Therefore this coincidence cannot be safely predicted in advance.

INTRODUCTION

Since the signing of the International Convention on Biological Diversity (CBD) in Rio in June 1992, most countries of the world have become committed to the safeguard and protection of their biodiversity resources in several ways that are explained in the Convention. Prior to safeguarding biodiversity resources of any country, it is essential to know first what a country has, and where. This is why strenuous efforts have lately been invested by both international organizations and by national Governments alike, in mapping biodiversity, and in inventing novel ways for such mapping (Moran *et al.* 1996). Mapping the distribution of species of plants and animals, however, can be traced back to Carolus Linnaeus, Von Humboldt, and Charles Darwin. Governments of today, having realized the high value of their wild biological resources, and the novel meanings of biodiversity (DeLong 1996), are determined to conserve these resources and are in need to find out about their distributions, in order to make rational decisions about their conservation. These decisions are primarily concerned with the problems of how and where to invest money in establishing nature reserves and about creating the legal frameworks for such areas, that are to be judged as worthy of protection, because of certain attributes of their biodiversity.

Several attempts have been made by the scientific community to put biodiversity on maps, on various scales, in order to facilitate and to optimize the process of implementing the CBD. For the global scale, we may refer to the works of the World Conservation Monitoring Center (WCMC 1992), the International Council for Bird Preservation (ICBP 1992), and to atlases such as that by Heinrich and Hergt (1993). For the regional scale we may refer to Gaston and David (1994) for Europe, and to Kassas (1996) for the southern Mediterranean. The evolutionary approach was used by Crame (1997) for the Polar regions. For the national scale we may refer to Kassas (1993) for Egypt, Carey *et al.* (1996) for Scotland, and EGPN (1997) for France. As for methodologies we may refer to Scott *et al.* (1993), who used GAP analysis, and again to ICBP (1992).

In order to facilitate decision making about conservation of biodiversity, Myers (1990) proffered the idea of hot spots, which are spots rich in biodiversity and at the same time exposed to imminent threats, so that they will need immediate protective action (Ghabbour 1996 a, 1997). A team of researchers at the Scottish Natural Heritage (Carey *et al.* 1996, Usher and Balharry 1996, and Usher 1997), have developed a methodology for the purpose of identifying biodiversity hot spots, as well as "cold spots", which are spots of low diversity. These too need attention to find out reasons for their poverty in species and try to remedy their situation.

In the present study, we shall attempt to use the available data on the diversity of higher plants in Egypt, in conjunction with twelve taxa from the Animal Kingdom, to see if the diversities of these taxa coincide, i.e., if spots of high diversity, and of low diversity, are the same for all of them. The purpose is to focus conservation efforts on these spots (or regions).

MATERIAL AND METHODS

Sources of Data

Data on the biodiversity of higher plants was obtained from El-Hadidi (1992), El-Hadidi and Fayed (1994/1995), El-Hadidi and Hosni (1996), and El-Hadidi *et al.* (1996). The 12 taxa of the Animal Kingdom were all insects. These are: (1) butterflies (Larsen 1990), (2) "other" Lepidoptera (Scoble 1994) and some important Families of Coleoptera (Alfieri 1976), namely, (3) Tenebrionidae, (4) Scarabaeidae, (5) Carabidae, (6) Cicindelidae, (7) Anthicidae, (8) Buprestidae, (9) Chrysomelidae, and (10) Histridae. Moreover, the study also included two Families of the Order Hymenoptera: (11) Formicidae (Mohamed 1979), and (12) Sphecidae (Gad Allah 1994). These animal taxa range from the rank of Family to the rank of Order. Some of these taxa are supposed to be intimately associated with plants, such as butterflies and "other" Lepidoptera.

Because of wide discrepancies among authors in defining the subdivisions of the main biogeographic regions of Egypt, we chose, as a first approximation, to apply this investigation of association between phyto-diversity and zoo-diversity in the five main phyto-geographical regions of Egypt: the Mediterranean coastal land (from Rafah to Salloum), the Western Desert (including the Oases), the Nile land (Delta and Valley), the Eastern Desert (including Gebel Elba), and Sinaï (excluding the Mediterranean coastal strip).

In the case of the Western Desert, we assumed that the figure of 160 plant species by El-Hadidi and co-workers for the Western Desert *per se*, is included in the figure of 285 plant species given for the Oases, and so we used only the latter figure for this main phyto-geographic region. In the case of the main phyto-geographic region designated as Nile land, the figure of plant species given by El-Hadidi and co-workers is 676, of which 470 are weeds, and 42 are water plants. We chose to use the total figure of 676 species, because water plants exist also in the other phyto-geographic regions, particularly in the Oases, but their numbers are relatively small, and were not excatly known at the time of the calculations. The figure of 676 species for the Nile land also includes 42 desert species for the Delta, and 18 for Aswan.

Statistical Treatment

Data (the absolute numbers of species) were treated by advanced multifactorial statistical methods, namely, factorial correspondence analysis (CA) and ascending hierarchic classification (AHC), using the absolute numbers of species in each taxon, in each main phyto-geographical region. AHC was applied on the results of the CA ordination by the DATAVISION programme (Roux 1985 and 1987). Another run was made using the percentage of species of each main phyto-geographical region to the number of species of the same taxon in the region having the highest number of species of that taxon (considered as 100%).

The data were also treated for multiple correlation after their normalization: absolute numbers of species were transformed into logarithms, while percentages were treated by applying the arcsin transformation (Ayyad and El-Bayoumy 1978).

RESULTS

Table 1 gives the absolute number of species of higher plants and twelve animal taxa in the five main phyto-geographical regions of Egypt. It is evident that although the Mediterranean coastal strip is about only 80,000 km sq. in area (about 8% of the area of the country), it has more than half of the Egyptian flora, which comprises 2121 species (Boulos 1995, see also Boulos 1997). The Sinaï Peninsula comes next with a little less than half the flora of Egypt. We used the figure of 984 species of El-Hadidi *et al.* (1996), although Boulos (1995) expanded it to 1262 taxa, because the latter figure includes the infraspecific taxa. The Nile land, with about only 6% of the area of the country, comes next with almost one third of the flora of the country. The Western Desert, the largest of the five regions in area, is the poorest in plant species. Because of its aridity, its plant life is almost wholly confined to the Oases, having very small areas, in addition to their isolation. The concentration of plant species richness in the Mediterranean can be attributed to its rainfall endowment, and in Sinaï to its unusual rugged terrain, added to its position, acquiring plant species from the Levant. The richness of plant life in the Nile land, on the other hand, can be attributed to agriculture, providing sufficient water for plant growth (mesophytes and hydrophytes, as well as some xerophytes on the edges).

Taken separately, the numbers of species belonging to each of the animal taxa selected, do not reach the level of higher plants. There is even one Family, Histridae, apparently absent from one of the regions, the Western Desert, which is also remarkably poor in most other coleopterous Families considered here. This Family is poorly represented in the Eastern Desert also. Order Lepidoptera, the only taxon of the rank of Order considered here, is well represented in all regions, but still with lower numbers in both the Western and Eastern Deserts. The coleopterous Family with highest numbers is Tenebrionidae, well known as a typical desert Family of Coleoptera, followed by Carabidae and Scarabaeidae. Cicindelidae, a predacious Family of Coleoptera like Carabidae, is very poorly represented.

The CA ordination (Fig. 1) of the data in Table 1 shows that the Western Desert is well separated from the other four regions, but has no characteristic taxa of its own, although with weak affinities for Formicidae (ants) and Lepidoptera (including butterflies). The Nile land is clearly characterized by five animal taxa: Scarabaeidae, Carabidae, Anthicidae, Buprestidae, and Sphecidae. The group of the Eastern Desert, the Mediterranean coastal strip, and Sinaï are close to each other and are the ones characterized by plants, but by only two animal taxa: Tenebrionidae, and Cicindelidae. The latter two taxa are therefore the only animal taxa whose geographical pattern of diversity coincides with that of plants, if sheer numbers of species is taken as a criterion. However, one of these two animal taxa, Tenebrionidae, is detritivorous, while the other, Cicindelidae, is carnivorous. In other words, none of them is herbivorous, i.e., none is directly related to plants for food or shelter. This separation of the latter three regions explains 68% of the variance. In this ordination, Chrysomelidae and Histridae have no special affinities with any region, though weakly related to all regions except the Western Desert.

The CA ordination of the previous data (Fig. 2), when taken in each region as percentage of the region with the highest number of species for each taxon, given in Table 2, shows that the Western Desert is in fact characterized by two animal taxa: Formicidae (ants), and Lepidoptera, while the Eastern Desert is characterized by one animal taxon: the Chrysomelidae. Histridae lose their affinity to the Eastern Desert. The Nile land joins the Mediterranean coastal strip and Sinaï as a group having rather strong affinities with the rest of the animal taxa, together with plants. In this run, the separation of the Western Desert from the other four regions explains only 39% of the variance, due to the smaller differences of the data set, since they are calculated as percentages.

A third run was carried out using the same percentage data as in Table 2, but using only the three regions which are so close to each other in Fig. 2, namely, the Nile land, the Mediterranean coastal strip, and Sinaï (Fig. 3). The three regions are more widely separated from each other, and it appears that only the Mediterranean coastal strip and Sinaï share the high plant diversity, with four animal taxa: Tenebrionidae, Scarabaeidae, Chrysomelidae, and Cicindelidae. The Nile land, on the other hand, is characterized by four animal taxa: Lepidoptera (including butterflies), Carabidae, Buprestidae, and Sphecidae. Histridae, Anthicidae, and Formicidae are no longer associated with any one of the three regions treated here, although weakly related to the Nile land. This separation explains 65 % of the variance.

This treatment shown in Fig. 3 could focus more sharply on the issue of coincidence between phyto-diversity and zoo-diversity in Egypt, as it appears that four taxa: Tenebrionidae, Scarabaeidae, Chrysomelidae, and Cicindelidae, are the only animal taxa of the 12 treated here, whose diversity strongly coincides with plant diversity in Egypt, in the Mediterranean coastal strip and in Sinaï. The first three of these four animal taxa are detritivorous, while the fourth is carnivorous, i.e., none is directly related to a particular plant food.

The correlation coefficients of the taxa of the five main phyto-geographical regions were calculated, once for the numbers of species, as given in Table 1 (but normalized to log), and a second time for the percentages, as given in Table 2 (after arcsin transformation). Table 3 gives these correlation coefficients.

All relationships in Table 1 (absolute numbers of species) are very highly significant, except in only one case, that of the Mediterranean coastal strip with the Western Desert. At the same time, none of the data in Table 2 (percentages) shows any statistically significant correlations with each other.

DISCUSSION

Mapping the biodiversity of a given country can be organized at three levels: the biogeographical regions of the country, its administrative divisions, and/or by a neutral grid of squares overlain on the map of the country. For mapping the biodiversity of a given country at any one, or all, of these levels, it is important to combine all possible taxa, not each taxon separately, because a Government needs to obtain the fullest possible benefit and advantage of their conservation efforts, to conserve the maximum of their biodiversity. Knowing that conservation efforts are usually meager, in comparison to other investments in other areas, a Government normally, and understandably, needs to obtain the fullest benefit from the least effort, i. e., it needs to optimize its expenditure of money and effort.

In this study, it appears that the coincidence between phyto-diversity and zoo-diversity is not something that can be predicted *a priori*. Animals obtain from plants both food and shelter, and therefore should theoretically follow plants and be closely associated with them. But animals have a wide variety (diversity) of needs from their environment, and the presence of plants, though crucial, is only one of these needs. According to their ecological functions, animals may use plants directly if they are herbivorous, but the close relationship may not be so clear if animals are predators, or even detritivorous. In the present study, regions particularly rich in plant diversity in Egypt, the Mediterranean coastal strip and Sinaï, are not characterized by Lepidoptera, which are typical herbivores. In the treatment shown in Fig. 2, it is in the Western Desert that we have the characteristic diversity of Lepidoptera, and in Fig. 3, it is the Nile land which seemingly is most preferred by Lepidoptera (when the Western and Eastern Deserts are eliminated from the ordination treatment). Similar to the present study, Goodman and Meininger (1989) found that the Nile land, the Mediterranean coastal strip (Deltaic and northern Sinaï only), as well as southern Sinaï, are the regions with highest number of birds found breeding. In their half degree grid map of Egypt, every grid square in the Nile land, as well as some squares in northern and southern Sinaï, has between 41 and 61 breeding bird species (the highest numbers recorded). Other squares with the same species density are in Hurghada area on the Red Sea coast and Gebel Elba (both Eastern Desert). In the Western Desert, similar bird species densities are found only in Kharga and Dakhla Oases.

The Scotland study (Carey *et al.* 1996), it is to be noted, reached the same conclusion of the non-coincidence between phyto-diversity and zoo-diversity. It used 3 taxa of the Plant Kingdom: liverworts, mosses, and vascular plants, and 4 taxa of the Animal Kingdom: breeding birds, wintering birds, diurnal insects, and molluscs, on a 10 km square grid map. Nevertheless, this study, as well as the present one, is useful in limiting the biodiversity map of the country into three types of hot spots: (1) hot spots rich in phyto-diversity alone, (2) hot spots rich in zoo-diversity alone, and (3) hot spots rich in both phyto- and zoo-diversity. This will help in limiting to a minimum the number of hot spots that will need immediate protection, by concentrating on the third category, and hence in optimizing Government efforts and expenditure.

Gaston & David (1994) used an equal area square grid of approximately 152,000 km sq. for Europe. They used ferns, gymnosperms, willows, dragonflies, hawkmoths, noctuine moths, butterflies, freshwater fish, amphibians, reptiles, birds, and mammals. Even if their study was somewhat weakened by the inclusion of aquatic animal and plant taxa (dragonflies, freshwater fish and amphibians, and water-loving willows) in the analysis, together with terrestrial species, which confounded the analysis to a notable extent, they again found no obvious simple patterns, i.e., a non-coincidence of phyto- and zoo-diversity for Western and Central Europe. They found, though, that they could identify most hot spots occurring in southern Europe, in what we may call the extra-Mediterranean Alpine band, a huge ridge extending from the Pyrénées to the Carpathian Mountains. This was predictable, since the region is highly rugged, hence a good environment for speciation and local endemism, for which it is known.

Although endemism in plants usually coincides with endemism in animals, because it is a phenomenon related to the same causative factors, principally isolation in oases, or of valleys in mountainous countries (e.g., endemism in Turkey is high for both plants and insects, Akkaya 1998), it is curious to note that phyto-diversity does not necessarily coincide with zoo-diversity, neither in Egypt, nor in Scotland, nor for Europe. Should we consider this a universal phenomenon? To try to explain these results would be a very complicated matter indeed. Certainly more cases are needed before reaching such a sweeping conclusion. But reasons for these concordant results (areas of concentration of plant diversity are not necessarily areas of concentration of animal diversity) are probably, in one aspect, and at least for the present case, due to the fact that here we have studied among plants, the diversity of wild plants only. This is because we are interested from the start in optimizing the conservation of wild plants, by combining their conservation with the conservation of the wild animals. The consideration of only wild plants rules out a study of the relationship between the diversity of wild fauna and that of cultivated crops. We did not account therefore for the diversity of crops, hosts of, for example, of many Lepidoptera of Egypt, especially in the Nile land. Another source of discrepancy may be that we aggregated the plant species of the Mediterranean coastal strip, from the figures given by El-Hadidi and co-workers for its three sectors: 360 for Mareotis, 225 for the Delta, and 171 for coastal Sinaï, adding up to 1083, though many are certainly common between any two of these sectors, or of all three.

A second reasson that is peculiar to desert regions is the role of plants and animals in the ecosystem, and in its development over time. In the research by M. Kassas and his school of plant ecology in Egyptian deserts (Kassas and Imam 1954, Kassas and Girgis 1965, and Kassas 1966), it was shown that plant succession is allogenic, meaning that physical factors are the dominant factors in controlling the phases of this succession. Plants that grow in a certain time and place in a desert are selected from an extremely narrow assemblage of hardy species that can withstand harsh conditions of drought and heat. The species are therefore not present as a result of their mutual interrelationships, but rather due to selection by physical factors of each species independently of the other species in the same system. In other words, any species could be associated with any other species if the two have siomilar reactions towards the prevailing environmental conditions. This does preclude that some species (particularly trees and shrubs), may provide favourable environmental conditions for some other species (e.g., shade). These are the key-stone or edificator species, and when present, they have a prominent role in species structure of the community. It is quite possible that animal ecology in deserts is also allogenic, and there is no reason to assume the contrary. Here may be the reason for the non-coincidence of animal diversity with plant diversity, since both are controlled by physical factors, and not by their own mutual interactions.

One more reason is related to the diversity of the functional roles of animals in the ecosystem (herbivores, carnivores, and detritivores), which may lead us to think that carnivores are not to be considered as closely associated with plants. Consequently we may suppose that carnivorous taxa are influenced by other factors, plant diversity not being one of them. However, two fully carnivorous taxa, Carabidae and Cicindelidae, though seemingly similar in their food requirements, did not follow a common pattern in our treatments. Carabidae, the more species rich of the two, showed rather close affinity to the Nile land, while Cicindelidae showed a close Mediterranean affinity. This latter affinity may then be attributed to zoogeographic affinities, rather than to anything else.

Scavenger taxa (or detritivores), such as Tenebrionidae, Scarabaeidae and Formicidae, again showed differences in their phyto-geographical associations. In Fig. 2, Formicidae have clear affinities to the Western Desert, while the former two are divided between the Nile land, the Mediterranean, and Sinaï. This means they have no special affinity to any particular one of these three regions. In Fig. 3, on the other hand, Formicidae have a clear preference for the Nile land, while the former two taxa are equally divided between the Mediterranean and Sinaï, i.e., common to both. At any rate, the present results show that the diversity of no animal taxon seems to be especially coincident in its affinities with the diversity of plants, even at this level of ordination, although they showed very highly significant correlations in at least one treatment (Table 3). These some time coincidences and some other times no coincidences between plant diversity and animal diversity seem to be of the type "now you see it, now you don't".

It must be admitted that the absence of a clear-cut coincidence between animal diversity and plant diversity even at the level of this preliminary study is not a strange finding. The great contrast between climatic (Fayed 1994) and geomorphological (Gouda 1994), and ecological conditions of desert and Nile (Ayyad and Ghabbour 1986), and of the Mediterranean coast (Ayyad and Ghabbour 1993), or of the mountainous and rugged Sinaï Peninsula (Ayyad and Ghabbour 1986), may partially help to explain such a discrepancy.

In the case of the Sinaï Peninsula, in particular, plant diversity is higher than anywhere else in Egypt: Boulos (1995) recognizes 1285 plant taxa from Sinaï, of which 23 are doubtful records, leaving 1262 taxa, including the infraspecific taxa (see also Boulos 1997). He also attributes 33 endemic species for Sinaï, in addition to 4 common between Sinaï and the rest of Egypt, out of 61 endemic species for the whole country. Even for cultivated plants, endemism is remarkable for Sinaï. According to Rabinowitz (1980), there are close to 400 gardens in the mountains of southern Sinaï, each just a tiny spot surrounded by rocks, and some of the fruit trees are endemic. In the case of the Mediterranean coastal strip, its recent geological history and higher rainfall of the Pleistocene, as well as its role as a corridor with other neighbouring Mediterranean countries (Ayyad and Ghabbour 1993, Ghabbour 1996 b) may account for its high biodiversity. The high biodiversity of the Nile Valley, also a corridor with tropical Africa (Ayyad and Ghabbour 1986, Ghabbour 1996 b), can be similarly explained.

The questions to be asked now, however, from this preliminary study, should be:

(1) Should species richness, for a more precise analysis, be taken as sheer numbers of species, or number of species per area? The very large Western Desert has fewer species than the other regions, and the Mediterranean coastal strip and the Nile land have larger numbers of species on a very much smaller area. Using the parameter of species numbers per area, with these data, would probably give qualitatively the same results, but quantitatively sharper indications.

(2) Does species richness in animals follow: (a) plant species richness (number of species), (b) plant density (number of plants per unit area), (c) plant biomass, (d) plant cover (percent ground covered by plants), (e) the abundance of certain plant species that play a certain role in the survival of animals, (f) ecological functions, or (g) biogeographic considerations (as probably in the case of Cicindelidae)? Or probably a varying number, and in varying degrees, of these vegetation characteristics put together, for each animal taxon?

(3) Are ecological factors which determine species richness of plants in one region, notably moisture and temperature régimes, the same as those which determine species richness of animals in the same region? And do they influence that parameter in the same way(s)? The answer is apparently no, they are not the same and they influence species numbers of plants and animals in different ways. It is possible, however, that a given animal species may be closely associated with a given plant species, but this is not necessarily true for all animal species of a given region, and hence it should not in any way mean that the entire fauna of a region must be associated with its entire flora. In other words, plants and animals of a given region may constitute a biocoenosis associated with the biogeographical region, rather than with each other. In this way, their numbers should not necessarily be approximately the same, i.e., species richness of the taxa of one Kingdom may not necessarily be similar to those of the other Kingdom. It is known that species to be found in particular parts of the world are there as a result of the combined effects of geographical, historical, and ecological factors (Odum 1993). Ecological factors include physical, chemical, and biotic factors. Biotic interactions between animals and plants are thus only one component of ecological factors, and these in turn act within the context of geographical and historical factors. Thus biotic interactions are not the sole determinants of the co-existence of certain animal species with certain plant species, although they have a role in it. It becomes clear therefore that the coincidence of phyto-diversity and zoo-diversity is not something that should be expected, or that can be safely predicted in advance.

(4) In spite of the already known poverty of the Western Desert, due to its aridity, and lack of prominent topographic features, it is evident that it has not been adequately surveyed. Birds, which may be the animal taxon most thoroughly documented in Egypt, have not been recorded in very large tracts of the Western Desert. The grid map given by Goodman and Meininger (1989) shows that in the Western Desert, bird records are made, besides in the Oases, mostly along the desert roads linking these Oases to each other, while the large sectors through which there are no roads, are almost devoid of records. The map shows one empty grid square in northern Sinaï, 4 in the northern Eastern Desert, 9 in the southern Eastern Desert, and 162 (!) in the Western Desert. Are these tracts really devoid of breeding birds, or is it that ornithologists did not venture into them? The question that naturally arises now, is whether all parts of Egypt are really well covered geographically for animal diversity, as we might suppose, given the multitude of records in the phyto-geographical regions which appear at first glance to be well covered for zoo-diversity, such as, notably, the Nile land, and the Mediterranean coastal strip, where physical difficulties for collecting samples are relatively mild, and provide ample opportunity for collecting biodiversity information, whether for phyto- or for zoo-diversity.

Apparently there is no one answer to these questions. The situation must be followed more thoroughly in the field, and for every animal taxon, and calculations made for each case separately. A more thorough investigation involving the administrative units of the country, and a half-degree grid, like that used for the case of birds (Goodman and Meininger 1989) is urgently needed to discern these issues and to help decision makers in deciding upon priority choices for protected areas, or for the delimitation of protected areas in existence now, or planned for the future. This becomes the more important to clarify since the National Egyptian Biodiversity Strategy envisages raising the proportion of protected areas of the country from its present 7.5% to 15% within 20 years (NBU 1997).

To conclude, results show that the Mediterranean coastal strip, the Nile land, and Sinaï, in general, combine the highest number of taxa with highest biodiversity, in both plants and animals (among those studied), while the Western Desert is the region with the lowest number of species in all taxa examined. The Mediterranean coastal land, the Eastern Desert, and Sinaï, have similar and intermediate degrees of species richness. It is difficult, however, at this stage, to decide whether the diversity of a given animal taxon, of any rank, is really associated with phyto-diversity. This is governed by several factors, among which may well be the incomplete recording of animal taxa in the various phyto-geographical regions of Egypt.

This type of study, if pursued, should greatly help decision makers in evaluating areas to be declared as protected nature reserves in Egypt, but it should be continued in greater detail for a finer taxonomic analysis of the sub-divisions of the main phyto- (or rather bio-) geographical regions of Egypt:

(1) Nile Delta, with its western, middle, and eastern parts, and Valley, with its northern, middle, and southern parts, in addition to Fayoum, and the Nubia Nile,

(2) the Oases of the Western Desert,

(3) the wadis of the northern and southern sectors of the Eastern Desert, and Gebel Elba,

(4) the three Mediterranean sectors (Mareotis, Deltaic, and Sinaïtic),

(5) north (Isthmic Desert) and south Sinaï,

(6) the Oases and the "empty quarters" of the Western Desert.

In addition to this, the study should cover a finer detail of the administrative divisions (e.g., Governorates); as well as the scale of a half-degree grid, successfully used by Goodman and Meininger (1989) for birds.

This study has shown that the coincidence of phyto-diversity and zoo-diversity is not something that can be expected or that can be safely predicted in advance, because geographical and historical factors are also involved, so that biotic interactions are not the sole determinants of this coincidence. This study should therefore be greatly improved by adding more animal taxa, whose distribution records in Egypt are already well documented, such as mammals, reptiles, Curculionidae (weevils), which are *a priori* thought to be intimately associated with their host plants, and soil fauna (particularly soil mites), which are known to be "conservative" taxa, i.e., that remain in the ecosystem for some time after the plant cover is removed and/or changed (Ghabbour 1991). The study should, moreover, be enriched by a finer division of both plant and animal taxa, according to their bio-geographical affinities (Ethiopian, Mediterranean, Asiatic), in addition to their ecological amplitudes of various environmental factors, including human influences. For plants, we should refine the study by the analysis of associations of animals with plants of different life-forms, by Families, and by ecological requirements (hydro-, meso-, or xerophytes). For animals, the study should be refined by analysis according to their ecological functions, e.g., herbivorous, carnivorous, or detritivorous, size, shelter and reproductive requirements.

The approach of conserving areas rich in biodiversity resources just because they have a high number of taxa of several taxonomic groups, seems logical, but is not the only possible, or plausible approach. This approach means that we are conserving sheer numbers (quantity) regardless of the value or quality of the species concerned. A spot poor in species may be rich in useful species, threatened, rare, or endemic species. Admittedly the conservation of spots with high numbers of species should not be the only objective of conservation efforts, and never sufficient as a uni-lateral conservation strategy. There are many other criteria for declaring conservation areas, but species richness usually comes in the forefront. However, decision makers will need to know how biodiversity, in general, of a maximum number of taxa, and not separately, of only few taxa, is distributed over the country. This study was therefore started to find out whether it is possible to propose the declaration of a protected area on grounds of its rich biodiversity in both the Plant and Animal Kingdoms, and not on grounds of richness of only one of these two biodiversity Kingdoms. It will be useful to pursue further this study in finer detail, on the basis of taxonomic, functional, and biogeographical criteria.

ACKNOWLEDGEMENT

The authors wish to acknowledge the kind help offered by Prof. M. Kassas (Cairo University) in revising the manuscript.

REFERENCES

AKKAYA, A. (1998): General evaluation on biological diversity in Turkey flora and insect fauna. *Egyptian-Swedish Symp. Commemorating Vivi Täckholm's 100th Birthday, Book of Abstracts*, Feb. 8-11, 1998, Bot. Dept., Fac. Sci., Cairo Univ.: 12. (abstract only).

ALFIERI, A. (1976): The Coleoptera of Egypt. **Mém. Soc. entomol. d'Egypte, 5:** 362 pp.

AYYAD, M. A. and EL-BAYOUMY, M. A. (1978): On the phytosociology of sand dunes of the Western Mediterranean Desert of Egypt. In: *Glimpses of Ecology (Professor R. Misra Commemoration Volume)*, eds. J. S. Singh and B. Gopal, Int'l Sci. Publ., Jaipur, India: 219-237.

AYYAD, M.A. and GHABBOUR, S. I. (1986): Hot deserts of Egypt and the Sudan. In: *Ecosystems of the World, Hot Deserts and Arid Shrublands*, vol. 12B, eds. D. W. Goodall *et al.*, Elsevier, Amsterdam: 149-202.

AYYAD, M.A. and GHABBOUR, S. I. (1993): Dry coastal ecosystems of Eastern North Africa. In: *Ecosystems of the World, Dry Coastal Ecosystems*, vol. 2B, ed. E. van der Maarel, Elsevier, Amsterdam: 1-16.

BOULOS, L. (1995): *Flora of Egypt Checklist*. Al-Hadara Press, Cairo: 283 pp.

BOULOS, L. (1997): Endemic flora of the Middle East and North Africa. In: *Reviews in Ecology: Desert Conservation and Development, A Festschrift to Prof. M. Kassas on the Occasion of his 75th Birthday*, eds. H. N. Barakat and A. K. Hegazy, Metropole Press, Cairo: 229-260.

CAREY, P.D.; HILL, M.O. and FULLER, R.J. (1996): Biodiversity hotspots in Scotland. *Scottish Natural Heritage Research, Survey and Monitoring Report*, No. 77: 74 pp.

CRAME, J. A. (1997): An evolutionary framework for the Polar regions. **J. Biogeog., 24:** 1-9.

DELONG, D.C. Jr (1996) Defining biodiversity. **Wildlife Soc. Bull., 24:** 738-749.

EGPN (1997): *La Diversité Biologique en France, Programme d'Action pour la Flore et la Faune Sauvages*. Comité de Recherche "Ecologie et Gestion du Patrimoine Naturel (EGPN)", Ministère de l'Environnement, Paris: 318 pp.

EL-HADIDI, M. N. (1992): Egypt's biological diversity, systematic botany, Gymnospermae and Angiospermae. Paper presented at: *Workshop on Egypt's National Biodiversity Strategy*, Nov. 1992, National Biodiversity Unit, Egyptian Environmental Affairs Agency, Cairo: 12 pp. (typescript).

EL-HADIDI, M.N. and FAYED, A.A. (1994/1995): Materials for Excursion Flora of Egypt. **Taeckholmia, 15:** 233 pp.

EL-HADIDI, M.N. and HOSNI, H.A. (1996): Biodiversity in the flora of Egypt. In: *The Biodiversity of African Plants, Proc. XIVth AETFAT Congress, 1994*, Kluwer Acad. Publ., Dordrecht, the Netherlands: 785-787.

EL-HADIDI, M. N.; HOSNY, A. I. and EL-HUSSEINI, N. (1996): Aspects of the biodiversity of the weed flora in the farmlands of Egypt. **Idem.** : 788-794.

FAYED, Y. A.-M. (1994): Climate of Egypt. In: *Geography of Egypt*, eds. Y. Aboul-el-Haggag, N. E. Nasr, M. S. Ghallab, and M. S. Abdel-Hakim, Higher Council for Culture, General Egyptian Book Organization, Cairo: 93- 134.

GAD ALLAH, N. S. (1994): *Taxonomic and Phylogenetic Studies on Some Sphecidae in Egypt.* Ph.D. Thesis, Dept. of Entomology, Fac. of Science, Cairo University.

GASTON, K. J. and DAVID, R. (1994): Hotspots across Europe. *Biodiversity Letters* 2: 108-116.

GHABBOUR, S. I. (1991): Towards a zoosociology of soil fauna. **Rev. Ecol. Biol. Sol., 28:** 77-90.

GHABBOUR, S.I. (1996 a): *Biodiversity hot spots in North Africa.* Paper presented at: Expert Meeting, IUCN North Africa Biodiversity Project, July 1996, Tripoli, Libya: 25 pp. (typescript).

GHABBOUR, S. I. (1996 b): Soil fauna diversity in arid lands of North Africa. In: *Biodiversity in Arid Lands of North Africa. Proc. Regional IUCN North Africa Workshop on Biodiversity in Arid Lands of North Africa*, Dec. 1994, eds. K. H. Batanouny and S. I. Ghabbour, Nat'l Egyp. IUCN Committee (Acad. of Sci. Res. & Techn.) and IUCN, Cairo: 73-89.

GHABBOUR, S. I. (1997): Threats to biodiversity in Arab countries. In: *Reviews in Ecology: Desert Conservation and Development, A Festschrift to Prof. M. Kassas on the Occasion of his 75th Birthday*, eds. H. N. Barakat and A. K. Hegazy, Metropole Press, Cairo: 129-157.

GOODMAN, S.M. and MEININGER, P.L. (1989): *The Birds of Egypt.* Oxford Univ. Press: xxii+551 pp.

GOUDA, G.H. (1994): Geomorphology of Egypt. In: *Geography of Egypt*, eds. Y. Abou-el-Haggag, N. E. Nasr, M. S. Ghallab, and M. S. Abdel-Hakim, Higher Council for Culture, General Egyptian Book Organization, Cairo: 47-90.

HEINRICH, D. and HERGT, M. (1993): *Atlas de l'Ecologie*. Librairie Générale Française, Lyon: 284 pp.

ICBP (1992): *Putting Biodiversity on the Map, Priority Areas for Global Conservation.* International Council for Bird Preservation, Cambridge, UK: 90 pp.

KASSAS, M. (1966): Plant life in deserts. In: *Arid Lands, A Geographical Appraisal*, ed. E. S. Hills, Methuen & Co., London: 145-179.

KASSAS, M., ed. (1993): *Habitat Diversity, Egypt.* National Biodiversity Unit, Egyptian Environmental Affairs Agency, Cairo, Publ. No. 1: 302 pp.

KASSAS, M. (1996): Biodiversity in the southern Mediterranean. **Environmental Awareness, 19(3):** 85-90.

KASSAS, M. and IMAM, M. (1954): Habitat and plant communities in the Egyptian Desert. III.- The wadi bed ecosystem. **J. Ecol., 42:** 424-441.

KASSAS, M. and GIRGIS, W. A. (1965): Idem. VI.- The units of a desert ecosystem. **Ibid., 53:** 715-728.

LARSEN, T. B. (1990): *The Butterflies of Egypt.* Apollo Books, the Amer. Univ. in Cairo: 112 pp.

MOHAMED, A. H. (1979): *Taxonomic Studies of Family Formicidae (Hymenoptera) in A. R. E.* Ph.D. thesis, Dept. of Zoology, Fac. of Science, Univ. of Ain Shams, Cairo.

MORAN, D.; PEARCE, D. and WENDELAAR, A. (1996) Global biodiversity priorities: A cost-effectiveness index for investments. **Global environ. Change, 6:** 103-119.

MYERS, N. (1990): The biodiversity challenge: Expanded hot spot analysis. **The Environmentalist, 10:** 243-256.

NBU (1997): *Egypt: Towards a National Strategy for Conserving Biological Diversity. (A Discussion Document for the National Conference).* National Biodiversity Unit (NBU), Central Administration for Nature Protection, Egyptian Environmental Affairs Agency, Council of Ministers, and UNEP, Cairo: 85 pp. (in Arabic).

ODUM, E. P. (1993): *Ecology and Our Endangered Life-Support Systems.* 2nd edition, Sinauer Assoc. Inc., Sunderland, Mass., USA: 301 pp.

RABINOWITZ, D. (1980): *St. Catherine: Nomination for World Heritage List.* Unpublished IUCN Doc., Gent: 14 pp. (typescript).

ROUX, M. (1985): *Algorithmes de Classification.* Masson, Paris: 151 pp.

ROUX, M. (1987): *DATAVISION 1.2, Logiciel d'Analyse de Données.* CEPE/CNRS, Montpellier: 30 pp.

SCOBLE, M.J. (1994): *The Lepidoptera, Form, Function and Diversity.* The Natural History Museum, Oxford Univ. Press: 404 pp.

SCOTT, J. M.; DAVIS, F.; CSUTI, B.; NOSS, R.; BUTTERFIELD, B.; GROVES, C.; ANDERSON, H.; CAICCO, S.; D'ERCHIA, F.; EDWARDS JR., TH. C.; ULLIMAN, J. and WRIGHT, R. G. (1993) GAP analysis: A geographic approach to protection of biological diversity. **Wildlife Monographs, 123:** 41 pp.

USHER, M. B. (1997): *Scotland's biodiversity: An overview.* Unpublished typescript: 32 pp.

USHER, M.B. and BALHARRY, D. (1996): *Biogeographical zonation of Scotland.* Scottish Natural Heritage, Edinburgh: 32 pp.

WCMC (1992): *Global Biodiversity, Status of the Earth's Living Resources.* World Conservation Monitoring Center, Cambridge, Chapman & Hall, London, UK :585 pp.

Table 1 - Number of species of higher plants and 12 animal taxa in the 5 main phyto-geographical regions of Egypt.

Taxon / Region	MCS	WD	NL	ED	S
Plants	1083	285	676	433	984
Butterflies	9	8	24	11	16
Other Lepidoptera	107	93	220	54	108
Tenebrionidae	134	43	151	47	128
Scarabaeidae	64	10	87	22	64
Carabidae	81	30	137	30	64
Cicindelidae	7	2	6	2	5
Anthicidae	34	7	55	12	17
Buprestidae	45	17	80	20	55
Chrysomelidae	38	1	50	42	38
Histridae	28	0	31	4	10
Formicidae	39	36	77	27	24
Sphecidae	47	14	121	24	53

MCS = Mediterranean Coastal Strip, WD = Western Desert (including the oases), NL = Nile land (including Delta and Valley), ED = Eastern Desert (including Gebel Elba), S = Sinai.

Table 2 - Percentage of species of higher plants and 12 animal taxa in the 5 main phyto-geographical regions of Egypt, as percent of the region with the highest number of species.

Taxon / Region	MCS	WD	NL	ED	S
Plants	100	26	62	40	91
Butterflies	38	33	100	46	67
Other Lepidoptera	49	42	100	25	49
Tenebrionidae	89	28	100	31	85
Scarabaeidae	74	11	100	25	74
Carabidae	59	22	100	22	47
Cicindelidae	100	29	86	29	71
Anthicidae	62	13	100	22	31
Buprestidae	56	21	100	25	69
Chrysomelidae	76	2	100	86	76
Histridae	90	0	100	13	32
Formicidae	51	47	100	35	31
Sphecidae	39	12	100	20	44

MCS = Mediterranean Coastal Strip, WD = Western Desert (including the oases), NL = Nile land (including Delta and Valley), ED = Eastern Desert (including Gebel Elba), S = Sinai.

Table 3 - Correlation coefficients (r) of higher plants and 12 animal taxa in the 5 main phyto-geographical regions of Egypt. Lower left hand corner of the table for correlation coefficients using log transformation of the original data as in Table 1, upper right hand corner of the table for correlation coefficients using arcsin transformation of percentage data as in Table 2.

r	MCS	WD	NL	ED	S
MCS	1.000	-0.164	-0.763	0.620	0.513
WD	0.770	1.000	0.203	-0.660	0.121
NL	0.942 *	0.827 *	1.000	-0.890	-0.537
ED	0.913 *	0.805 *	0.918 *	1.000	0.474
S	0.954 *	0.825 *	0.940 *	0.955 *	1.000

MCS = Mediterranean Coastal Strip, WD = Western Desert (including the oases), NL = Nile land (including Delta and Valley), ED = Eastern Desert (including Gebel Elba), S = Sinai.

The asterisk (*) denotes significance at the 0.001 level.

All other correlations not significant.

LEGEND TO FIGURES

Fig. 1 - Ordination by Factorial Correspondence Analysis (CA) of data in Table 1, with application of the Ascending Hierarchic Classification (AHC) technique on the results of the ordination.
E = Easrtern Desert, M = Mediterranean coastal strip, N = Nile land, S = Sinaï, W = Western Desert.
1 = plants, 2 = butterflies, 3 = "other" Lepidoptera, 4 = Tenebrionidae, 5 = Scarabaeidae, 6 = Carabidae, 7 = Cicindelidae, 8 = Anthicidae, 9 = Buprestidae, 10 = Chrysomelidae, 11 = Histridae, 12 = Formicidae (ants), 13 = Sphecidae.

Fig. 2 - Ordination by CA of the percentage data in Table 2. Symbols as for Fig. 1.

Fig. 3 - Ordination by CA of the percentage data in Table 2, but after eliminating columns of the Western and Eastern Deserts. Symbols as for Fig. 1.

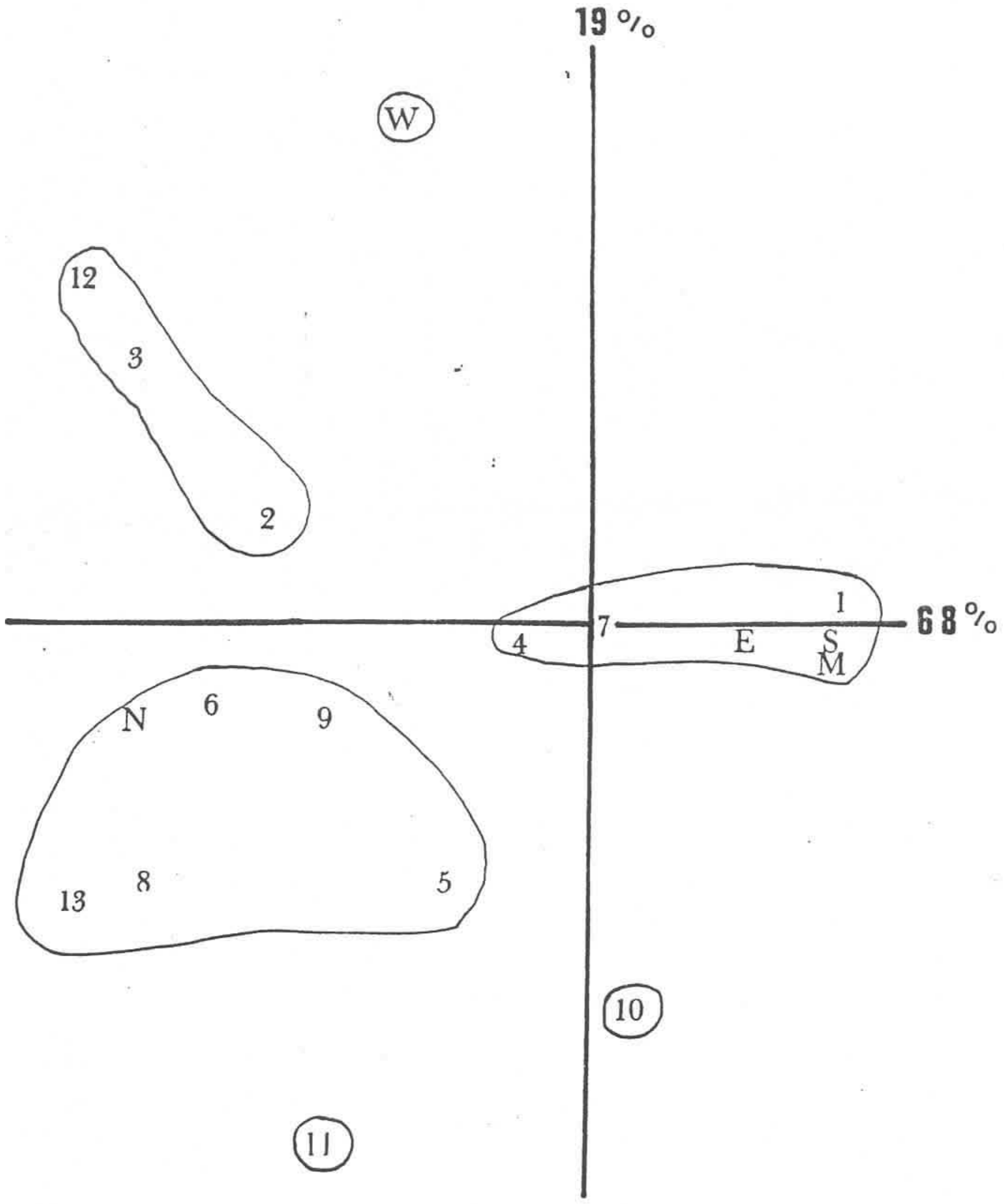

Fig. 1

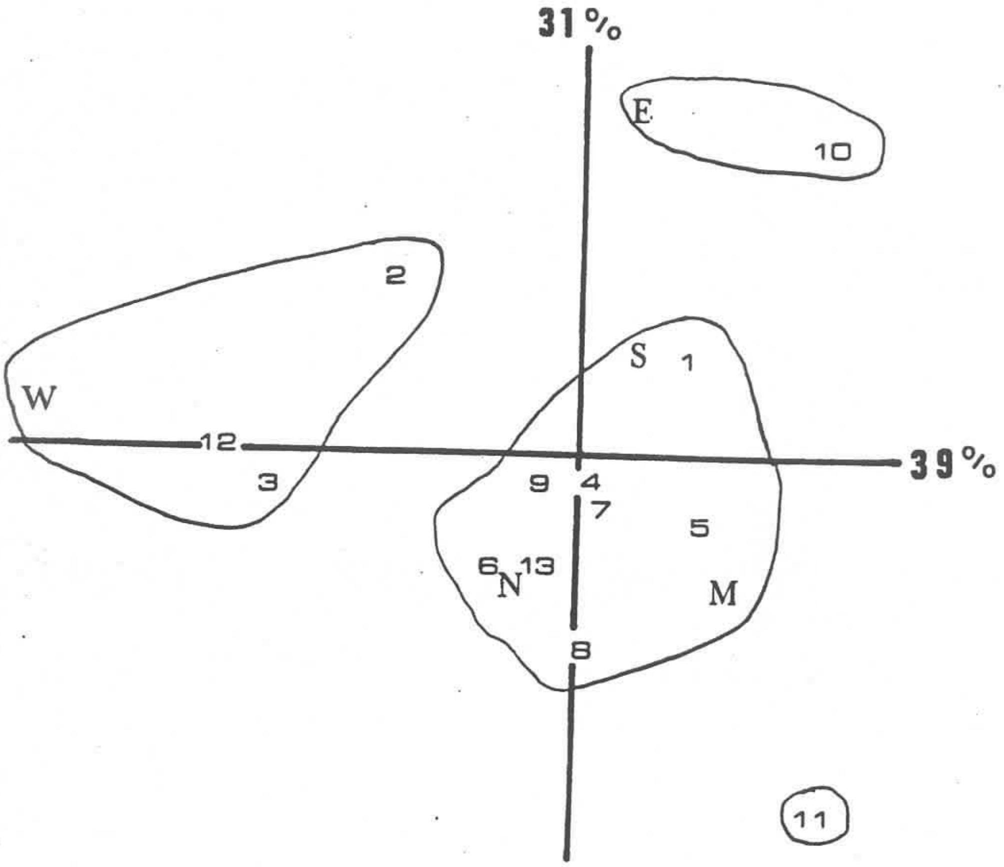

Fig. 2

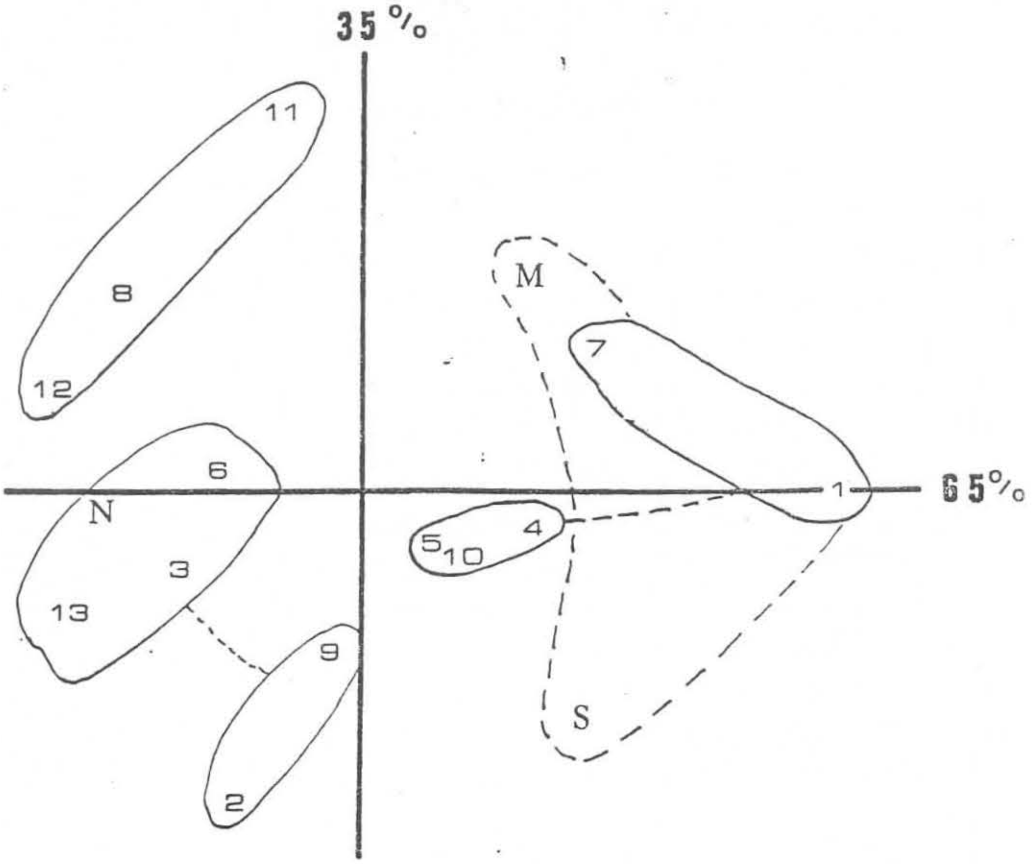

Fig. 3

ISSN 1110 - 5380
مجلة إتحاد البيولوجيين العرب
الندوة المصرية - السويدية للأحتفال بمرور مائة عام على ميلاد أ.د.. فيفى تاكهولم (٨-١١ فبراير ١٩٩٨)
العدد الخامس (B) علم النبات

هل يتصادف التنوع النباتي مع التنوع الحيواني في مصر؟

سمير ابراهيم غبور[١] - وفائى زكى عازر ميخائيل[٢]

قسم الموارد الطبيعية[١] و معهد البحوث و الدراسات الأفريقية[٢] ، جامعة القاهرة

منذ توقيع الاتفاقية الدولية للتنوع البيولوجى في مدينة ريو دى جانيرو بالبرازيل عام ١٩٩٢ أصبحت دول العالم ملتزمة بالحفاظ على التنوع البيولوجى و استخدامه استخداما رشيدا و متواصلا. و لكن يجب أن يسبق هذا أن تعرف الدولة ما تملكه من هذا التنوع و أين يوجد. و بذلك اكتسبت المسوح الجادة للتنوع البيولوجي و وضعه على خرائط أهمية متزايدة لدى الحكومات من أجل التعرف على الأماكن الغنية بمثل هذا التنوع بغرض حمايتها و حسن الاستفادة منها، و اتخاذ قرارات اختيار المواقع الجديرة بأن تعلن محميات طبيعية، و لحسن توزيع الموارد المالية اللازمة لتنفيذ تلك الحماية. .و الشائع أن مثل هذه المحميات الطبيعية يتم إعلانها في المواقع التي تتميز بالثراء في تنوعها البيولوجى، و حيث يتعرض هذا التنوع البيولوجى الثرى لخطر الاختفاء لمختلف الأسباب. و تعرف مثل هذه المناطق حاليا بمصطلح "النقاط الساخنة". هناك الآن إذن حاجة إلى وضع التنوع البيولوجى على خرائط تفصيلية، و على مستويات مختلفة و على اتساعات جغرافية مختلفة: العالمي، و الإقليمي، و القطري، و المحلى. و بالنسبة للمستوى القطري هناك ثلاث أساليب لوضع مثل تلك الخرائط، أن تكون على مستوى الأقسام البيوجغرافية، أو الأقسام الإدارية، أو على شبكة من مربعات محايدة ذات مساحات متفاوتة تغطى كل مساحة الدولة. و لكي تكون مثل هذه الخرائط مفيدة، يجب أن تجمع أكبر عدد ممكن من الأنواع، النباتية و الحيوانية على نفس الخريطة، كي تستطيع الحكومة اتخاذ القرار الصائب بخصوص إعلان المناطق المحمية، و أن تنفق أقل قدر ممكن من الأموال في سبيل حماية أكبر عدد ممكن من الأنواع المتباينة، حتى تحصل على أكبر عائد ممكن من جهودها في حماية التنوع البيولوجى الذي تملكه.. و قد تم حتى اليوم توقيع توزيعات أنواع النبات في مصر، و كذلك الزواحف و الفراشات، على أساس الأقسام البيوجغرافية (أو قل الأقسام الفيتوجغرافية)، و بالنسبة للطيور على أساس شبكة مربعات طول الضلع منها نصف درجة. و لم تحدث محاولة حتى الآن للجمع بين توزيعات الأنواع النباتية و الحيوانية في خريطة موحدة. و قد جمعنا في البحث الحالي بين توزيعات التنوع البيولوجى للنباتات الراقية و أثنى عشر مجموعة تقسيمية حيوانية، كي نتعرف على مدى التصادف بين هذه التوزيعات (على أساس عدد الأنواع). و تدل النتائج الأولية و بصفة عامة، أن وادي النيل و الدلتا يضمان العدد الأكبر من كل من الأنواع النباتية و الحيوانية التي اختيرت، بينما ظهرت الصحراء الغربية كأفقر الأقسام البيوجغرافية طرا في هذه الأنواع. و قد أظهرت الدراسة أن التفاعلات البيولوجية و الأيكولوجية بين الأنواع النباتية من جهة و الأنواع الحيوانية من جهة أخرى، ليست هي العامل الأساسي في تحديد التصادف بينها، أو في تحديد المواقع المتمتعة بالثراء النوعي لكل من المملكتين النباتية و الحيوانية في ذات الوقت، بل إن هناك عوامل أخرى ما زالت مجهولة و تحتاج إلى الدراسة حتى يمكن ترشيد الأنفاق في هذه السبيل، حيث أن التصادف بين التنوع البيولوجى و ثرائه، للنبات البرى و للحيوان البرى، في مصر على الأقل، ليس مما يمكن التنبؤ به مسبقا.